S'COOL BREEZE

Student's Cloud Observations On-Line

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NASA Scientists Use Empty Skies to Study Climate Change

By Julia Cole, NASA Langley

When the tragic events of September 2001 temporarily halted U.S. commercial air traffic, it created an opportunity to study the relationship between aviation and clouds. From satellite observations taken during the air traffic shutdown, NASA scientists gained insight into the atmospheric conditions that govern the formation of contrails -- clouds caused by aircraft emissions.

Jet Contrails: NOAA image; Flagstaff, AZ

"Because air traffic is expected to grow over the next 50 years, contrail coverage will also increase and may significantly impact the Earth's radiation budget by 2050," said Patrick Minnis, a senior research scientist at NASA's Langley Research Center in Hampton, Va.

The Earth's radiation budget -- the balance between the planet's incoming sunlight and outgoing heat energy -- drives climate change. Contrails can spread into extensive high, thin cirrus clouds that tend to warm the Earth because they reflect less sunlight back to space than the amount of heat they trap.

Tracking the formation of contrails is key to determining their contribution to cirrus clouds and their effect on the energy balance. Contrails typically form in large numbers from overlapping commercial flights, making it difficult for scientists to follow their development.

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Inside this issue:

Contrail Science

By Roberto Sepulveda

Contrails behind the engines of a large aircraft.

Well, what exactly is a contrail? The word "contrails" comes from 'condensation trails,' which typically refers to line-shaped clouds produced by jet airplane engine exhaust. This 'condensation' event typically occurs at 8-12 km (about 5-7 miles) above the Earth's surface. Contrails are composed primarily of water in the form of ice. Jet engine exhaust emits water vapor into the surrounding air. The water vapor is a by-product of jet fuel combustion. Tiny particles (aerosols) are also emitted and provide a surface for water droplets to form. Contrails form when the water droplets freeze to form ice particles. Another factor affecting contrail formation is the humidity (amount of atmospheric moisture) along the airplane's path. If the humidity is low the contrails will evaporate quickly; these are called 'short-lived' contrails. If the humidity is high the contrail will continue to grow; these are called 'persistent spreading' contrails. Persistent contrails can last for hours and can grow considerably in width and height. They often spread due to differences in wind speed along the flight path. You've probably wondered why contrails don't appear daily. We have learned how atmospheric

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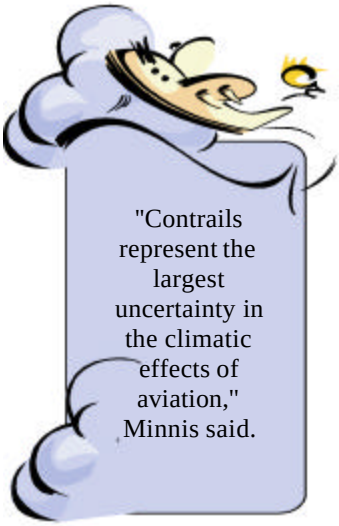
(**NASA Scientists:** Continued from page 1)

The air traffic shutdown gave Minnis and his team the chance to track individual, persistent contrails from military aircraft on September 12.

"Six aircraft were responsible for the formation of cirrus clouds that covered more than 20,000 square kilometers within an area between Virginia and central Pennsylvania," said Minnis. "During normal days, the area is crossed by thousands of jetliners that could each produce contrails similar to those from the military jets."



"Contrails represent the largest uncertainty in the climatic effects of aviation," Minnis said.

The results of the study provide the basis for improved prediction of persistent contrails and their effects on climate.

Digital photograph taken through the windows of the International Space Station shows contrails over Eastern France

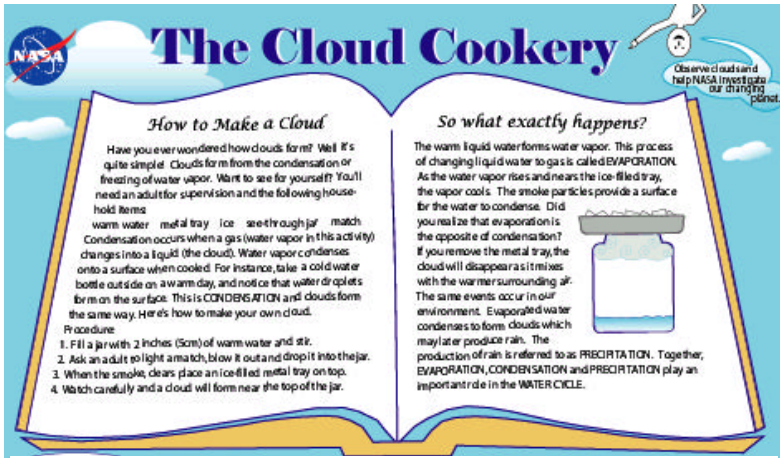
"If scientists determine that contrails are negatively impacting climate change, we could minimize their formation by predicting where they will occur and then suggesting alternate flight altitudes accordingly, when feasible," said Minnis. David Duda, of Minnis' team, has used improved estimates of relative humidity (the amount of water vapor in the atmosphere) from Minnis' study to enhance computer simulations of contrails and their predictability.

NASA STEMS

NASA Science **T**rivia
to **E**xcite & **M**otivate **S**tudents

By now it's not a mystery that scientists are studying contrails. But did you know that contrails were first noticed during high-altitude flights in the 1920's? However, interest in contrails really blossomed during WWII when bombers could be sighted from miles away. In fact, numerous WWII veteran accounts tell of problems to aviation due to massive contrail formations. Planes could not find their targets, and sometimes collided with each other. The picture to the left depicts one of the oldest contrail photos. It was taken during dogfights over London's St. Paul's Cathedral during the Battle of Britain in 1940.

Introducing



S'COOL is proud to present the much awaited accompaniment to our

CLOUD IDENTIFICATION CHART

We would like to take this opportunity to thank the scientists and editors here at NASA for their assistance in the production of 'The Cloud Cookery.' In addition, a special 'Thank You!' goes out to all the S'COOL participants who helped by sending in comments and suggestions. Students will learn how to make their own cloud, the history of cloud nomenclature, the importance of their ground truth observations and some basic principles about observing. Students can print their own color copy by visiting our website at: http://asd-www.larc .nasa.gov/SCOOL/Cloud_ID.html

Quarter's Worth of Websites

Vinny : http://vinny.pcs.cnu.edu

The Vinny™ Awards is a contest to produce a one minute video that explains how Science, Technology, Engineering and/or Mathematics (STEM) is being used or can be used to help solve a global problem. Examples of such problems include pollution, food distribution or maybe even 'climatic effects of contrails.' Teams of students work with a teacher and a mentor to research the global problem of concern to you and people you know. Grade ranges include elementary, middle, or high school.

GLOBE: http://www.globe.gov/

GLOBE is a worldwide hands-on, primary and secondary school-based education and science program. For Students, GLOBE provides the opportunity to learn by taking scientifically valid measurements, reporting data and collaborating with scientists. For Teachers, GLOBE provides training workshops, teacher's guides, videos and other materials.

(**Contrail Science:** Continued from page 1)

temperature and humidity are key factors affecting contrail formation. Since both of these factors undergo daily and seasonal changes, contrails may or may not form over a given location.

So why are scientists interested in contrails? Clouds are the largest variable controlling Earth's atmospheric temperature and climate. Any increase in global cloud cover will contribute to long-term changes in Earth's climate. Likewise, any change in Earth's climate may have effects on natural resources. Contrails produce an increase in the Earth's cloudiness. We can now clearly understand that while contrails do not pose a direct threat to humans, the need for contrail research exists to address long-term changes in climate. Scientists are most interested in persistent contrails because they form clouds that would not normally have formed in the atmosphere. Persistent contrails can last for hours and spread, becoming indistinguishable from naturally occurring cirrus clouds. Student observers can collaborate with scientists by observing contrail cover in their area and reporting on the amount and type of contrails present. Persistent contrails are currently estimated to cover about 0.1% of the Earth's surface (note the predominant gray area in figure 1). It is estimated that this will increase considerably over the next four decades (note the increase in dark areas over the US, Europe and Asia – see figure 2). Now that you have a better understanding of contrails, you can appreciate the need for global research on contrails. For more information about this article visit the EPA website at: http://www.epa.gov/otaq/regs/nonroad/aviation/contrails.pdf

Research aircraft captures this picture of contrails forming behind a commercial jet at 35,000 feet.

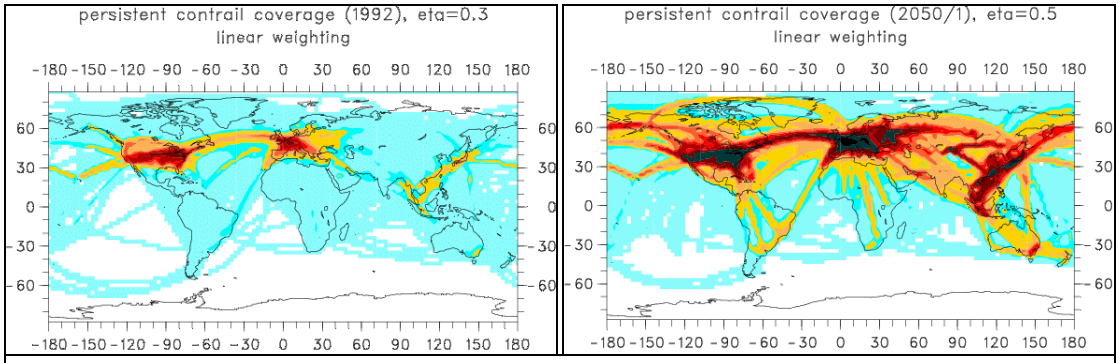


Fig. 1 & 2. Comparison of estimated global contrail coverage between 1992 and 2050.

The Winners of S'COOL's 2nd Cloud Photo Contest

Once again, the choice for the winners of the 2nd cloud photo contest proved difficult due, in part, to the high number of photos submitted. Information about the **3rd Cloud Photo Contest** will be in the September S'COOL Breeze. At this time we will once again ask our participants be on the lookout for that perfect cloud photo opportunity.

The WINNERS of S'COOL's Second Photo Contest

Cumulonimbus: Forest Park HS: Woodbridge, Virginia
Nimbostratus: Taipei Municipal Girls HS; Taipei, Taiwan
For a list of additional winners and their winning photos please visit our website at: http://scool.larc.nasa.gov

TeacherCorner

Wow, over 24,500 Observations submitted!
Keep up the OUTSTANDING work!

Has any of your registration information changed? Please remember to notify us !

NEW Student Participation Certificate

Don't forget to present this NASA award to your students!
Download and print this color certificate at:
http://asd-www.larc.nasa.gov/SCOOL/scool_cert.pdf

Thank you for your continued participation!

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Upcoming Events

Summer S'COOL Teachers' Workshop
June 23–27, 2003
NASA Langley Research Center
Hampton, VA USA

Our Star the Sun 2003 Summer Institute
July 12–21, 2003
Mayaguez, Puerto Rico

IOP–Intensive Observation Period
July 14–18. 2003

http://asd-www.larc.nasa.gov/SCOOL/visits.html

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"S'COOL: A student's view"

Students Cloud Observations On-Line (S'COOL) has greatly impacted me on how intimate science can be to the general public. Originally I had perceived scientific research to be "too difficult" for children; their reports might be erroneous, etc. But when I was visited by S'COOL, I grew aware that we can indeed become scientists in our own right: we help vindicate the data of satellites, beyond the earth itself!

Besides taking part in an important project, students can ask questions to enthusiastic scientists who always make an effort to find the answer. I personally have engaged in a correspondence between some of these scientists, and have found it a wonderful opportunity to harvest knowledge. It has also motivated me to choose CERES for the subject of my research report. S'COOL, I feel, can only bring self-esteem, motivation, and learning to the student (as I have experienced), while at the same time, assist NASA scientists with their research.

Abigail, student, age 10 , Hunterdon Christian Academy Flemington, New